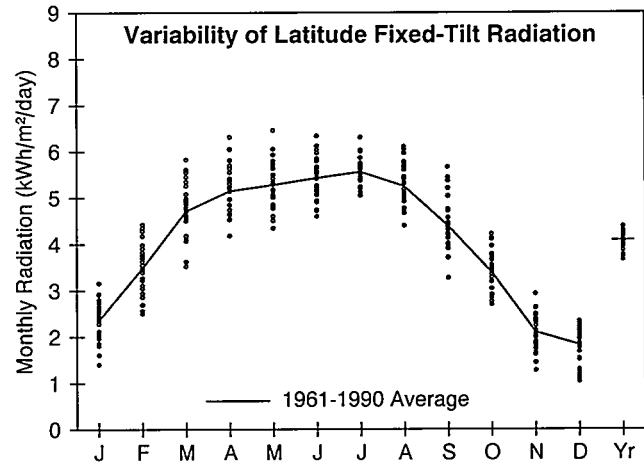


Houghton, MI

WBAN NO. 94814

LATITUDE: 47.17° N
 LONGITUDE: 88.50° W
 ELEVATION: 329 meters
 MEAN PRESSURE: 974 millibars

STATION TYPE: Secondary



Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m²/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	1.3	2.2	3.5	4.6	5.5	6.0	6.0	5.0	3.6	2.3	1.3	1.1	3.6
	Min/Max	1.0/1.6	1.7/2.6	2.8/4.1	4.0/5.3	4.6/6.6	5.2/7.0	5.5/6.7	4.3/5.7	3.0/4.3	2.0/2.7	1.1/1.6	0.7/1.3	3.3/3.8
Latitude -15	Average	2.1	3.2	4.5	5.2	5.6	5.9	6.0	5.5	4.4	3.2	1.9	1.6	4.1
	Min/Max	1.3/2.8	2.4/4.0	3.5/5.5	4.3/6.3	4.7/6.9	5.0/6.9	5.4/6.8	4.6/6.3	3.3/5.6	2.6/3.9	1.3/2.6	1.0/2.1	3.7/4.4
Latitude	Average	2.3	3.5	4.7	5.2	5.3	5.4	5.6	5.2	4.4	3.4	2.1	1.8	4.1
	Min/Max	1.4/3.2	2.5/4.4	3.5/5.8	4.2/6.3	4.3/6.5	4.6/6.3	5.1/6.3	4.4/6.1	3.3/5.7	2.7/4.2	1.3/2.9	1.0/2.3	3.7/4.4
Latitude +15	Average	2.5	3.6	4.7	4.8	4.7	4.7	4.8	4.7	4.2	3.4	2.1	1.9	3.8
	Min/Max	1.4/3.4	2.5/4.6	3.4/5.9	3.8/6.1	3.8/5.7	4.0/5.4	4.4/5.5	4.0/5.5	3.1/5.4	2.7/4.3	1.2/3.1	1.0/2.5	3.4/4.1
90	Average	2.4	3.3	4.1	3.7	3.0	2.9	3.0	3.2	3.2	2.9	2.0	1.8	3.0
	Min/Max	1.2/3.3	2.2/4.4	2.7/5.3	2.7/5.0	2.5/3.6	2.5/3.2	2.8/3.3	2.8/3.8	2.3/4.3	2.3/3.7	1.0/2.8	0.9/2.5	2.5/3.2

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m²/day), Uncertainty ±9%

Axis Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	1.8	3.1	4.9	6.3	7.4	8.1	8.1	6.9	5.0	3.2	1.7	1.4	4.8
	Min/Max	1.1/2.4	2.2/4.0	3.7/6.2	5.0/7.4	5.8/9.4	6.6/10.0	7.2/9.3	5.7/8.5	3.6/6.3	2.5/4.1	1.1/2.4	0.8/1.7	4.4/5.2
Latitude -15	Average	2.4	3.8	5.7	6.8	7.6	8.2	8.3	7.4	5.6	3.9	2.2	1.8	5.3
	Min/Max	1.4/3.3	2.7/5.0	4.2/7.2	5.4/8.3	6.0/9.8	6.6/10.1	7.3/9.6	6.0/9.1	3.9/7.3	3.0/5.0	1.3/3.2	1.0/2.3	4.8/5.8
Latitude	Average	2.6	4.1	5.8	6.8	7.4	7.8	8.0	7.2	5.6	4.0	2.3	2.0	5.3
	Min/Max	1.5/3.6	2.8/5.3	4.3/7.4	5.3/8.3	5.8/9.6	6.3/9.8	7.0/9.3	5.9/8.9	3.9/7.4	3.0/5.2	1.3/3.4	1.0/2.6	4.7/5.8
Latitude +15	Average	2.7	4.1	5.8	6.6	7.0	7.3	7.5	6.9	5.5	4.0	2.4	2.1	5.2
	Min/Max	1.5/3.8	2.8/5.5	4.2/7.4	5.0/8.2	5.4/9.1	5.9/9.2	6.6/8.7	5.6/8.5	3.7/7.2	3.0/5.3	1.3/3.5	1.0/2.7	4.5/5.6

Solar Radiation for 2-Axis Tracking Flat-Plate Collectors (kWh/m²/day), Uncertainty ±9%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2-Axis	Average	2.7	4.1	5.8	6.9	7.7	8.4	8.4	7.4	5.7	4.1	2.4	2.1	5.5
	Min/Max	1.5/3.8	2.8/5.5	4.3/7.4	5.4/8.3	6.1/10.0	6.8/10.4	7.4/9.8	6.1/9.1	3.9/7.4	3.0/5.3	1.3/3.5	1.1/2.8	4.9/6.0

Direct Beam Solar Radiation for Concentrating Collectors (kWh/m²/day), Uncertainty ±8%

Tracker		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
1-Axis, E-W Horiz Axis	Average	1.2	1.8	2.4	2.9	3.6	3.9	4.0	3.4	2.6	2.0	1.1	0.8	2.5
	Min/Max	0.5/2.0	1.1/2.7	1.6/3.4	2.0/3.7	2.3/5.3	2.8/5.4	3.1/5.1	2.4/4.6	1.5/4.0	1.1/3.0	0.3/2.0	0.3/1.3	2.2/2.9
1-Axis, N-S Horiz Axis	Average	0.8	1.5	2.6	3.7	4.7	5.3	5.3	4.5	3.1	1.9	0.7	0.5	2.9
	Min/Max	0.3/1.3	0.8/2.3	1.7/3.7	2.6/4.6	3.1/7.0	3.6/7.2	4.2/6.7	3.2/6.2	1.7/4.5	1.0/2.8	0.2/1.4	0.2/0.8	2.5/3.3
1-Axis, N-S Tilt=Latitude	Average	1.3	2.2	3.2	4.1	4.8	5.1	5.2	4.7	3.6	2.6	1.2	0.9	3.2
	Min/Max	0.6/2.2	1.3/3.3	2.1/4.6	2.9/5.1	3.1/7.0	3.5/6.9	4.1/6.5	3.4/6.5	2.0/5.4	1.4/3.8	0.3/2.3	0.3/1.4	2.8/3.7
2-Axis	Average	1.4	2.2	3.2	4.1	5.0	5.5	5.6	4.9	3.6	2.6	1.3	0.9	3.4
	Min/Max	0.6/2.4	1.3/3.4	2.1/4.6	2.9/5.2	3.3/7.4	3.8/7.6	4.4/7.0	3.5/6.7	2.0/5.4	1.4/3.9	0.4/2.4	0.3/1.5	3.0/3.9

Average Climatic Conditions

Element	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Temperature (°C)	-8.4	-7.7	-2.1	5.7	12.3	17.1	19.7	18.4	14.1	8.2	1.8	-5.2	6.2
Daily Minimum Temp	-13.1	-13.2	-7.7	-0.2	5.6	10.3	13.0	12.1	8.3	3.1	-2.0	-9.1	0.6
Daily Maximum Temp	-3.7	-2.2	3.4	11.5	18.9	23.8	26.4	24.7	19.9	13.2	5.6	-1.4	11.7
Record Minimum Temp	-32.2	-36.7	-30.6	-16.1	-6.1	-1.7	0.6	-1.7	-6.1	-8.9	-18.9	-29.4	-36.7
Record Maximum Temp	11.7	15.0	24.4	30.0	32.2	35.0	36.7	34.4	33.3	29.4	21.1	17.2	36.7
HDD, Base 18.3°C	828	728	634	380	199	67	19	39	130	315	497	730	4566
CDD, Base 18.3°C	0	0	0	0	11	28	62	41	0	0	0	0	142
Relative Humidity (%)	79	76	74	68	65	69	71	75	78	77	81	82	75
Wind Speed (m/s)	4.5	4.1	4.4	4.5	4.1	3.8	3.4	3.3	3.5	3.9	4.3	4.3	4.0